Physics Challenges for Teachers and Students

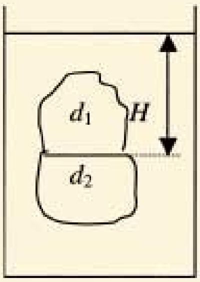
In this issue of *Physics Challenges* we present some problems dealing with fluids and thermodynamics.

Ping Pong? Not for Long!

How deep (h) must a ping-pong ball be submerged into the ocean so that it would sink when released? Assume that the ball can be "squeezed" but remains airtight; the temperature of the water is the same at any depth. The radius of the ball is $r = 2.00$ cm, its mass is $m = 3.00$ g, and the density of the material is $d_b = 1.40$ g/cm^3. The density of the ocean water is $d_w = 1.02$ g/cm^3. Assume also that the initial pressure inside the ball is close to the normal atmospheric pressure P_a.

Dense and Tense Story

Two objects of equal volume V and different densities d_1 and d_2 ($d_1 < d_2$) are glued to each other so that their contact surface is flat and has an area A. When the objects are submerged in a certain liquid, they float in stable equilibrium, the contact surface being parallel to the surface of the liquid (see the diagram). How deep (H) can the contact surface be in the liquid so that the objects are not torn apart? The maximum force that the glue can withstand is F.



Mystery, Alaska

A room is heated by a radiator that has a constant temperature T (unknown). When the outside temperature is 260 K, the room temperature is 300 K. However, when the outside temperature drops to 240 K, the room temperature is only 290 K. Estimate the radiator temperature T.

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It was encouraging to receive readers' responses to the first issue of *Challenges*, in the October issue. The solutions arrived not only from the United States, but also from Norway, Sweden, and the Netherlands! Below, we present the abbreviated versions of selected submitted solutions.

The Ball Stops Here

This problem can be solved by switching to the reference frame of the foot and treating the collision as an elastic collision of the ball and a "wall" (because the foot is much more massive than the ball). The foot (in the Earth frame of reference) must be moving at 6 m/s, away from the ball.

(*Hugh Haskell, Durham, NC*)

Bee Aware

As measured by the first bee, the second bee has a velocity $v_1 + v_2$ toward the first bee and a relative acceleration $a_1 + a_2$ away from the first bee. The first bee may thus consider the second one thrown "upwards" with initial velocity $v_1 + v_2$ in a gravitational field with acceleration due to gravity $a_1 + a_2$. The maximum "height" is

$$h = \frac{(v_1 + v_2)^2}{2(a_1 + a_2)} .$$

The initial separation D equals $(d + h)$;

$$D = d + \frac{(v_1 + v_2)^2}{2(a_1 + a_2)} .$$

(*Inge Pettersen, Stavanger, Norway*)

Gold in the Cold.

The key to the solution is in recognizing that the lowest period corresponds to the smallest orbit radius, which is equal to the (unknown) radius of the planet. Then for the satellite, introducing the radius of the planet *r*, its density *d*, the mass of the satellite *m* and the mass of the planet *M*,

$$F_G = F_c = mg = GmM/r^2;$$

$$M = dV = d4\pi r^3/3; \quad g = Gd(4\pi r/3) = v^2/r$$

$$T = 2\pi r/v = \sqrt{(3\pi/Gd)} = 45 \text{ min}$$

(*Göran Norlén, Lund, Sweden*)

Many thanks to these and all other contributors; we look forward to your solutions and your own favorite challenges!

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Photo of the Month

A Beautiful Example of Two-Point Interference

Baraboo High School physics teacher David Kinzer took this picture while camping on Whitefish Lake in Sylvania Wilderness of Michigan's Upper Peninsula last July. The circular waves were caused by the wing beats of two moths, visible just above and to the right of each circle center.

Photo by David Kinzer; kailswor@facstaff.wisc.edu